Research on the Integration Mechanism and Practical Pathways of the 5E Teaching Model and Case Teaching Under AI Empowerment—Taking the Applied Statistics Major in Higher Education Institutions as an Example

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Abstract: *With the rapid advancement of artificial intelligence technology, traditional applied statistics education in higher education institutions faces the challenge of cultivating students' ability to solve complex real-world problems. Addressing the highly practical nature of the applied statistics discipline, this study explores the deep integration of the 5E teaching model with case-based teaching methods, empowered by AI technology. The paper first analyzes the inherent compatibility between the 5E teaching model and case-based teaching, then systematically constructs an "5E-C-AI" integration mechanism model under AI empowerment, and elaborates on specific implementation pathways within applied statistics instruction. Research demonstrates that this integrated model effectively stimulates students' inquiry interest, deepens statistical thinking, and enhances their comprehensive abilities in data acquisition, processing, modeling, and interpretation, thereby providing a new paradigm for cultivating innovative and application-oriented statistics professionals.*

Keywords: *AI Empowerment; 5E Teaching Model; Case-Based Teaching; Applied Statistics; Integration Mechanism; Implementation Pathway*

1. Introduction

The core objective of Applied Statistics programs in higher education is to cultivate students' ability to utilize statistical theories, methods, and technologies to solve real-world problems. However, current teaching practices are often plagued by issues such as "emphasizing theory over practice," "focusing on calculation at the expense of interpretation," and "relying on singular teaching methods." These problems result in a disconnect between knowledge and practice, leaving students ill-equipped to handle the challenges posed by multi-source, high-dimensional, and unstructured data in the big data era.

The 5E instructional model, comprising the phases Engagement, Exploration, Explanation, Elaboration, and Evaluation, emphasizes student-centered active inquiry and knowledge construction. This model aligns highly with the "problem identification - analysis - resolution" workflow inherent to Applied Statistics [1]. Concurrently, the case-based teaching method provides students with a practical arena by presenting authentic, complex scenarios. The emergence of artificial intelligence technologies, particularly generative AI, big data analytics, and cloud computing, offers powerful tools for personalized learning, in-depth exploration, and efficient assessment. Therefore, researching the organic integration of these three elements to construct a new, intelligent, inquiry-based, and case-driven teaching model holds significant theoretical importance and practical value [2].

In this era of data-driven decision-making, Applied Statistics serves as a crucial bridge connecting the data world with real-world problems. The quality of its education directly impacts the ability to cultivate professionals with exceptional data analysis capabilities and strategic insight. Traditional case-based teaching, by simulating real-world scenarios, has become an indispensable component of Applied Statistics instruction, providing students with valuable practical experience. However, as the wave of big data and AI sweeps across industries, the limitations of traditional case-based teaching are becoming increasingly apparent: static cases struggle to match the dynamic evolution of the real world; pre-defined, clean datasets fail to adequately prepare students for the complexity and chaos of real data; linear, closed analysis processes are insufficient for fostering modern data science competencies, such as exploration, trial-and-error, and iteration in uncertain environments.

The rapid development of artificial intelligence, especially large language models and generative AI, presents a historic opportunity to break through these bottlenecks. AI empowerment represents far more than the mere addition of an auxiliary tool; it signifies a systematic upgrade and structural transformation of the philosophy, methodology, and ecosystem of case-based teaching in Applied Statistics. AI can generate vast quantities of realistic, customizable teaching cases, create highly simulated, interactive data analysis environments, and provide immediate, personalized feedback and guidance. This enables a shift in the teaching focus from traditional "knowledge transmission" and "skill training" towards the higher-order goals of "ability forging" and "thinking cultivation" – namely, developing students' core competency in navigating complexity and making data-driven strategic decisions in dynamic environments.

This paper explores the innovative pathways for case-based teaching in Applied Statistics empowered by AI. Focusing on the complete lifecycle of a data science project – from problem definition and data acquisition, through data cleaning, exploration, and visualization, and modeling analysis and interpretation, to result presentation and decision simulation – it elaborates on the specific empowerment scenarios and practical methods of AI at each stage. The aim is to construct a new paradigm for practical teaching that is future-oriented and deeply integrated with artificial intelligence, thereby providing a viable roadmap for cultivating outstanding statistics talent capable of leading in the digital age.

2. The Inherent Compatibility Between the 5E Instructional Model and Case-Based Teaching, and the Value of AI Empowerment

2.1 Analysis of the Inherent Compatibility Between the 5E Instructional Model and Case-Based Teaching

A natural, structured correspondence exists between the five phases of the 5E instructional model and the implementation process of case-based teaching. This compatibility makes cases an ideal vehicle for running through the 5E model, while the 5E model provides a clear and scientific procedural framework for case-based teaching.

The compatibility between "Engagement" and "Case Scenario Presentation". The purpose of the "Engagement" phase in the 5E model is to capture students' attention, activate their prior knowledge, and reveal the conflict between their existing cognition and the new situation, thereby sparking inquiry desire [3]. In case-based teaching, when students are presented with a real business dilemma, a thorny public health issue, or an intriguing social phenomenon, their curiosity and anticipation for "what happens next" are naturally stimulated. The core problem within the case directly creates a cognitive conflict for students, providing a clear goal and driving force for subsequent inquiry activities [4].

The compatibility between "Exploration" and "Case Analysis and Inquiry". In the "Exploration" phase, the core of the 5E model, students interact directly with learning materials through hands-on operations, experiments, investigations, data analysis, and other means, actively constructing new knowledge. The "analysis and inquiry" process in case-based teaching requires students to delve into case details, identify key information and distractors, consult relevant materials, utilize various analytical tools, engage in group discussions, and collectively explore the root causes of problems and potential solutions. These two are identical in essence, both emphasizing the central role of the student and the process of active inquiry.

The compatibility between "Explanation" and "Solution Formation and Reporting". The "Explanation" phase in the 5E model requires students to organize, articulate, and justify their inquiry processes and findings. They need to describe what they discovered and why, introducing scientific concepts and theories to support their viewpoints. "Solution Formation and Reporting" in case-based teaching, based on thorough inquiry, requires students to develop a complete set of solutions or decision recommendations and clearly articulate their analytical logic, decision-making basis, and expected outcomes through oral presentations, written reports, etc. Formulating a solution and defending it in case-based teaching constitutes the most profound "Explanation" process.

The compatibility between "Elaboration" and "Case Extension and Variation". The "Elaboration" phase in the 5E model aims to help students apply newly acquired knowledge and skills to new and different contexts, thereby consolidating learning and testing the depth and flexibility of their understanding. "Extension and Variation" in case-based teaching involves the instructor introducing similar "sister cases" or altering a key constraint of the original case after its resolution, prompting students to rethink their solutions. Case-based teaching naturally provides fertile ground for "Elaboration"; through variant practice, students learn that there are no universally applicable solutions and that they must flexibly apply learned principles according to the specific context.

The compatibility between "Evaluation" and "Whole-Process Assessment and Reflection". "Evaluation" in the 5E model is ongoing throughout the process. It includes summative assessment of outcomes but places greater emphasis on formative assessment, focusing on students' performance, ways of thinking, and collaborative skills at each phase. "Whole-Process Assessment" in case-based teaching evaluates not only the final solution report but also students' participation in case discussions, the depth of their problem analysis, logical rigor, teamwork spirit, and receptiveness to differing opinions. Both approaches transcend traditional pen-and-paper tests by adopting diversified assessment methods.

2.2 The Empowering Value of AI

AI can push differentiated case background materials or generate personalized problem scenarios based on students' prior knowledge levels. During the exploration phase, AI tools can assist students in rapidly performing data cleaning and exploratory analysis; generative AI can act as a "research assistant," providing suggestions for data preprocessing ideas or visualization. In the explanation phase, AI algorithms can help students quickly experiment with multiple models, shifting their focus from tedious coding to model selection, feature engineering, and result interpretation, thereby deepening their statistical thinking. For the elaboration phase, AI can dynamically generate new, similar simulated datasets or variant problems based on the original case, allowing students to practice applying knowledge flexibly. In the evaluation phase, AI can conduct preliminary reviews of students' code and data analysis reports, providing immediate feedback; meanwhile, instructors can use the common difficulties identified by AI analysis to conduct targeted explanations [5].

3. Construction of the "5E-C-AI" Integration Mechanism Model Empowered by AI

Based on the above analysis, we have constructed an integration mechanism model, as shown in Figure 1.

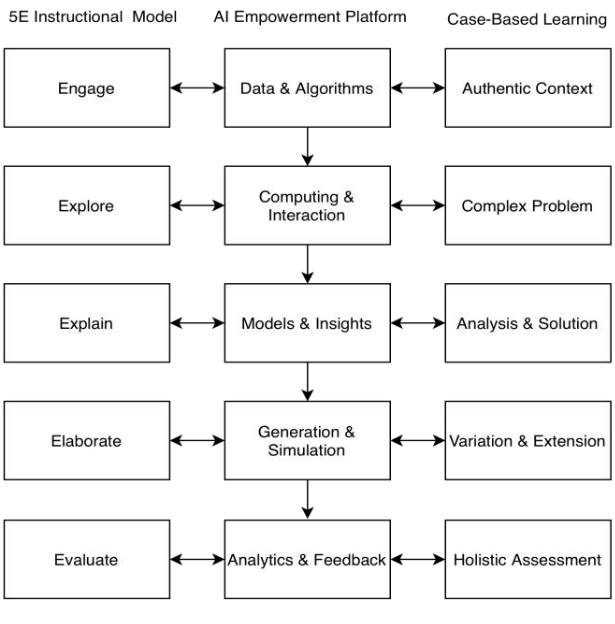

Figure 1. The AI-Empowered "5E-C-AI" Integration Model

The "5E-C-AI" model uses the case as its "anchor point," with the entire teaching activity revolving around a core case that runs throughout the entire 5E process. It follows the 5E model as its "framework," strictly adhering to the five phases of the 5E model to ensure that students' cognitive patterns are respected and the knowledge construction process is scientific and orderly. AI serves as its "enabling wing," embedding like a pair of wings into each teaching segment, functioning as a tool, assistant, and evaluator to enhance teaching efficiency and depth, thereby achieving personalization and intelligence that are difficult to attain through traditional teaching methods.

The design of this model adheres to the following six core principles to ensure its scientific validity, effectiveness, and operational feasibility.

3.1 The Principle of Structured and Sequential Teaching Process

Teaching activities must follow a scientific cognitive sequence, using the five stages of the 5E instructional model as the "instructional framework." This ensures that students' learning process forms a complete closed loop, progressing from situational perception and active inquiry to meaning construction and knowledge application, thereby aligning with cognitive laws that move from perceptual to rational and from simple to complex. In course design, every teaching unit or case must be explicitly mapped to these five stages to prevent arbitrariness and fragmentation in the teaching process.

3.2 The Principle of Authenticity and Anchoredness in Learning Contexts

The starting point and core driving force of learning must originate from authentic, complex, and ill-structured cases that "anchor" knowledge within specific contexts. This principle addresses the issue of disconnection between knowledge and practice, cultivating students' awareness, interest, and sense of responsibility when confronting real-world problems. The complexity of cases provides the necessary cognitive challenge for students, driving the occurrence of in-depth inquiry. High-quality cases closely related to the professional field should be carefully selected or designed to ensure they possess authentic backgrounds, conflicting elements, and an open-ended solution space.

3.3 The Principle of Deep Integration and Enhancement through Technological Empowerment

The application of AI technology must not be isolated or used for mere technical showcase, but must achieve deep and seamless integration with the 5E process and case content to enhance rather than replace students' cognitive processes. It should leverage AI to overcome the limitations of human cognition and traditional teaching tools, thereby freeing students from low-level and tedious tasks such as data cleaning and complex computations, and enabling them to focus on higher-order thinking activities including critical thinking, model selection, result interpretation, and decision-making.

3.4 The Principle of Student-Centered Inquiry and Construction

The entire model must be student-centered, ensuring students' central role in case inquiry. Knowledge is not passively instilled but is actively constructed by students through inquiry, collaboration, and reflection. This approach cultivates students' capacity for autonomous learning and lifelong learning. During the processes of exploration and explanation, students not only acquire knowledge but also develop scientific research methods, problem-solving skills, and a spirit of teamwork.

3.5 The Principle of Alignment and Dynamism in Teaching and Assessment

Teaching assessment must maintain a high degree of alignment with the competency objectives of each 5E phase and the knowledge and skills embedded in the case, and it must be integrated throughout the entire teaching process. This achieves the goal of "using assessment to promote learning." Formative assessment helps both instructors and students understand learning progress and difficulties in a timely manner, while summative assessment comprehensively tests the ability to transfer and apply knowledge. The model utilizes AI to implement dynamic and diversified assessment.

3.6 The Principle of Transferability and Extensibility of Applied Abilities

The endpoint of instructional design should not be the solution of a single case. Instead, it must include components specifically designed to promote knowledge transfer and ability expansion, cultivating students' capacity to apply knowledge flexibly. This ensures that the knowledge and skills students acquire are adaptable and vital, enabling them to cope with diverse future work scenarios and complex problems. During the "Elaboration" phase, "variant exercises" are deliberately designed to test and consolidate the transferability of learning outcomes.

4. Practical Pathway for Applied Statistics

Using the "E-commerce Platform User Churn Prediction" case as an example, the specific practical pathway is elaborated below.

4.1 Engagement – AI Creates Context and Stimulates Interest

The instructor uses AI video generation tools to quickly produce a short video demonstrating the significant losses user churn causes for an e-commerce platform. Simultaneously, generative AI is used to simulate profiles and behavior trajectories of different churned users, allowing students to intuitively understand the problem. The instructor then poses the core question: "Can we predict who is likely to churn in advance from user behavior data?"

4.2 Exploration – AI Assists Data Processing and Supports Independent Inquiry

Student groups obtain a simulated user behavior dataset containing noise and missing values. Students utilize AI-assisted coding tools or conversational AI to seek code suggestions for data cleaning and outlier handling. They employ automated visualization tools to rapidly explore variable distributions and correlations.

4.3 Explanation – AI Accelerates Modeling and Focuses Thinking

Students attempt to build models such as logistic regression, decision trees, and random forests. They utilize AutoML platforms to rapidly perform model tuning and comparison, thereby saving significant coding time. The students' focus shifts from "how to implement the model" to "why choose this model?", "how to interpret feature importance?", and "what is the business significance of the model results?". Generative AI can be prompted to role-play as a "business stakeholder," questioning students' model interpretations to deepen their understanding.

4.4 Elaboration – AI Generates Variants and Expands Capabilities

After completing the basic prediction model, the instructor uses AI to generate new tasks. For instance, the instructor might instruct the AI: "Please design an intervention strategy for users identified as high churn risk and evaluate its effectiveness," where the AI can generate simulated test data for students to analyze.

4.5 Evaluation – AI Enables Formative and Diversified Assessment

A multidimensional assessment system comprising "AI preliminary evaluation - instructor in-depth evaluation - peer evaluation" is established. The AI conducts initial checks on the structural completeness and code standardization of the data analysis reports submitted by student groups. The instructor then focuses on the reasonableness of students' model selection, the depth of their result interpretation, and the logical coherence of their reports. Utilizing an online collaboration platform, students engage in inter-group peer evaluations, concentrating on the innovativeness of the proposed solutions.

Through this pathway, the students we cultivate will no longer be mere "statistical technicians" who only apply formulas and models, but rather "data strategists" capable of leveraging AI, navigating vast oceans of noisy data, and providing robust solutions to complex business problems. This represents the essential upgrade and restructuring that Applied Statistics education must undergo in the AI era.

5. Challenges and Reflections

The application of AI presents challenges to the instructor's role, requiring a transition from knowledge transmitter to learning designer, facilitator, and promoter. Instructors need to become familiar with AI tools and capable of designing high-value inquiry activities. In the process of integrating the 5E instructional model with case-based teaching, instructors must prioritize case and data quality, meticulously designing or selecting cases that are highly aligned with course objectives, feature high-quality data, and can stimulate deep thinking. During implementation, attention must be paid to technical ethics and academic integrity. Instructors need to guide students in using AI correctly, avoiding over-reliance, emphasizing critical thinking, and establishing academic norms regarding AI use.

Conclusion

The integrated model of "the 5E instructional model and case-based teaching under AI empowerment" constructed in this study provides a systematic solution for teaching reform in Applied Statistics within higher education. By using cases as the driver, the 5E model as the process, and AI as the support, this model achieves an organic unity of knowledge transmission, ability cultivation, and quality enhancement. Practice demonstrates that this pathway can effectively enhance students' capabilities in statistical modeling, computational thinking, and decision-making communication within authentic data contexts. It represents a valuable exploration in cultivating outstanding applied statistics talent equipped to meet the demands of the intelligent era.

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